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INFLUENCE OF THE TYPE OF MOLECULAR COMPOUND ON THE CONCENTRATION OF ATOMS OF MATTER IN AN ALTERNATING CURRENT ARC WITH THE INJECTION OF SAMPLES BY AN AIR BLAST

A. V. Milyus

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INFLUENCE OF THE TYPE OF MOLECULAR COMPOUND ON THE CONCENTRATION OF ATOMS OF MATTER IN AN ALTERNATING CURRENT ARC WITH THE INJECTION OF SAMPLES BY AN AIR BLAST.

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The author investigates the method of determining the absolute concentration of atoms and the influence of the molecular composition of the sample on the concentration of nickel atoms in an alternating current arc flame. The sample is injected with an air blast. Both the degree of ionization and temperature are experimentally determined. The reproducibility of the analysis for atom concentration was 2-4 better using an air blast to introduce the sample than for the usual method of sample introduction. The temperature values, however, were 300-400°C higher with this new method. Various explanatory hypotheses are presented.

The method of introducing a sample by an air jet has come to be introduced widely in the practice of spectral analysis in recent years [1-5]. In [4, 6] it is shown that in the air injection method there is a sharp decrease in the influence of the chemical composition of the sample on the intensity of the spectral lines in comparison with the method of evaporation of a powder from the crater of a carbon electrode. /15*

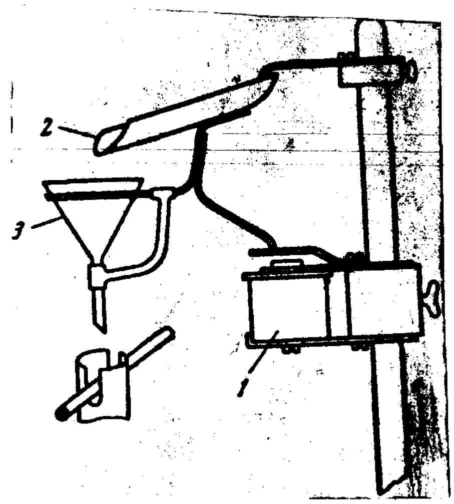
The objective of our study was an investigation of the method of determining the absolute concentrations of atoms developed by N. A. Prilezhayeva [7] and the influence of the molecular composition of the sample on the concentration of nickel atoms in an alternating current arc flame with the introduction of the sample by an air blast. Determination of the absolute concentrations of atoms in an arc discharge by this method essentially involves experimental determination of the degree of ionization and temperature. The temperature of the arc gas was determined in relation to the intensity of the lines Cu I 5105.6-Cu I 5218.2 Å. The probabilities of the transitions of these lines measured by Huldt and corrected using the new values of energy for the copper levels, were given in a study by V. N. Kolesnikov [8], which we also used. The degree of ionization of the easily ionized second component of the arc gas was determined in relation to the intensity of the ionic and atomic lines MG I 2779.8-Mg II 2798.1 Å. Nickel in the form of $NiCl_2$, $NiCO_3$ and $NiSO_4$ was used in the study. These compounds were selected for comparison of the results of this study and the data obtained in the study of M. A. Alekseyev [9]. The samples were prepared with carbon powder base with the addition of salt at the rate of 10% of the content of metal. For determining the temperature of the arc and the degree of ionization of the metal in the sample, $CuSO_4$ and $MgCO_3$ were

*/Numbers in the margin indicate pagination of the original foreign text.

introduced in a quantity of 1%. The samples were supplemented to 100% with charcoal powder.

The arc was fed from an alternating current source with a current of 6 amp and with a distance of 6 mm between the electrodes. The activator was a DG-2 generator. In all cases the working region of the flame was used, as proposed by A. K. Rusanov [10]. For this purpose the interelectrode gap was placed approximately 5-6 mm above the optical axis of the light source system.

A vibrator was used for introducing the powder into the discharge; this is shown in the Figure. The rate of the airflow, recorded by a rheostat and controlled by a manometer, was kept constant at 2 m/sec, as being most favorable for elements of average volatility [11].



Apparatus for Introducing Air Samples into the Arc. 1 = Electromagnet; 2 = Trough with a Scoop; 3 = Glass Funnel.

The survey of the spectrum was with an ISP-22 spectrograph. The exposure began 5 seconds after "free" combustion and continued for 30 sec with a 0.03-mm slit. The photographic material used was "isoorthochromatic" plates with a line sensitivity of 2 on the State Standard scale. About 100 photographs were taken for each sample; in each case 70 photographs were investigated thoroughly by photometric techniques and processed. /16

On each photograph we made a photometric study of the lines Mg I 2779.8, Mg II 2798.1 and Cu I 5105.6, Cu I 5218.2 Å; then we computed the values of the ratio of the line intensities of magnesium and the lines of copper. These ratios were used in determining the temperature (T) and degree of ionization (x_2) and then the concentration of Ni ions. The results of the computations are given in the table.

TABLE

Test	$x_2 \cdot 10^{-2}$	$\bar{x} \cdot 10^{-4}$	T, ° C	Ion Concentration Ni$\cdot 10^{-13}$
$NiCO_3$	14,02	5,28	5560±31,6	5,27±1,49
$NiCl_2$	11,9	5,78	5520±34,9	6,62±0,183
$NiSO_4$	18,5	4,06	5570±30,1	3,037±0,865

The relative error in measuring temperature is 0.6% and the absolute concentration is 18-28%.

The absolute concentrations of atoms in the arc gap which we determined are in satisfactory agreement in order of magnitude with the values obtained in [12, 13, 9, 7, 14, 15]. However, the concentrations of the samples which we took with an identical content of metallic nickel in the arc discharge differed from one another by a factor of 1.2-2 times, whereas these same nickel compounds in the studies made by M. A. Alekseyev [12, 9] give absolute concentrations in the arc discharge differing from one another by a factor of 2-5. Therefore, when using an air blast the reproducibility of the analysis increases by approximately 2-4 times in comparison with the usually-used spectral method of analysis based on the evaporation of ore from the electrode channel, which also is confirmed in the studies of A. K. Rusanov [3, 10]. The difference in the atom concentration in the plasma of the arc can be attributed, as in [12, 9], to a difference in the strength of the bond and the heats of sublimation of the atoms in the nickel in the molecular compounds which we used. However, the temperature values which we obtained were 300-400°C higher than the values in [9]. In such a case the mentioned factors should play a lesser role when using an air blast than when there is evaporation from electrodes. To be sure, this does not fully explain the dependence which we obtained. For an interpretation of this dependence it obviously is necessary to make use of the patterns of entry of substances into the plasma of the discharge and the subsequent escape of atoms from it into the surrounding atmosphere.

As noted by Ya. D. Raykhbaum in [4], the rate of evaporation of particles is dependent on their mass, duration of their presence in the flame of the arc and its temperature. Rusanov identifies the rate of flow of the air [11] injected into the arc with the rate with which the atoms, as a result of diffusion, are separated from the gas cloud that forms during the evaporation of particles. The commensurability of these factors is confirmed in [6], where the rate of diffusion of atoms is in good agreement with the rates of diffuse escape of atoms from the cloud of an arc found by Raykhbaum in [5] during the evaporation of matter from the channel of the carbon electrode.

Therefore, the rate of diffuse escape of atoms from the cloud is commensurable with the rate of removal of the products of evaporation by the air (2-4 m/sec) according to [6] and must be taken into account when explaining the change of atom concentration in the arc. Thus, in order to avoid the effect /17
of the influence of the composition of the powder it is necessary to carry out the analysis under conditions facilitating the complete evaporation of the particles.

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